CLAIMS

1. A device for generating an oscillating current, comprising:

an insulating layer positioned between at least two electrolyte reservoirs;

a negative bias electrode and a positive bias electrode, each electrode having one end in electrical communication with respective electrolyte reservoirs, the other ends of the electrodes being connected to a voltage source for applying a voltage and a current detector for measuring current;

at least one hole penetrating the insulating layer;

at least one pore positioned within each of the at least one hole, the at least one pore existing in one of an open and a closed state, wherein the closed state prevents ionic communication between the reservoirs and the open state allows ionic communication between the reservoirs to generate electrical current.

2. A device as in claim 1, wherein the at least one hole has a diameter of less than about 1 μm.

3. A device as in claim 1, wherein the at least one hole has a diameter of less than about 500 nm.

4. A device as in claim 1, wherein the at least one hole has a diameter of less than about 300 nm.

5. A device as in claim 1, wherein the at least one hole has a diameter of less than about 100 nm.

6. A device as in claim 1, wherein the at least one pore has a diameter of less than about 10 angstroms.

7. A device as in claim 1, wherein the at least one pore has a diameter of between about 3 angstroms and about 10 angstroms.

8. A device as in claim 1, further comprising the at least one pore being positioned in a lipid bilayer positioned within each of the at least one hole.

9. A device as in claim 8, wherein the at least one pore comprises the pore of an ion channel.

10. A device as in claim 8, wherein the ion channel comprises a closed ring arrangement of protein subunits.

11. A device as in claim 10, wherein the closed ring arrangement of protein subunits comprises at least 3 protein subunits.

12. A device as in claim 11, wherein the closed ring arrangement of protein subunits comprises between 3 and 15 protein subunits.

13. A device as in claim 12, wherein the closed ring arrangement of protein subunits comprises between 6 and 12 protein subunits.

14. A device as in claim 13, wherein each of the protein subunits is subunit c of ATP synthase.

15. A device as in claim 9, wherein the ion channel is selected from the group consisting of a sodium ion channel, a potassium ion channel, a calcium ion channel and combinations thereof.

16. A device as in claim 9, wherein the ion channel is a sodium/calcium ion channel.

17. A device as in claim 1, wherein the oscillation has a frequency of between about 0.1 Hz and about 700 Hz.

18. A device as in claim 1, wherein the current has a value of at least about 10 pA upon applying a voltage of between about 60 mV to about 100 mV.

19. A device as in claim 1, wherein the current has a value of at least about 50 pA upon applying a voltage of between about 60 mV to about 100 mV.

20. A device as in claim 1, wherein the current has a value of at least about 100 pA upon applying a voltage of between about 60 mV to about 100 mV.

21. A device as in claim 1, wherein the current has a value of at least about 200 pA upon applying a voltage of between about 60 mV to about 100 mV.

22. A device as in claim 1, further comprising an array of holes penetrating the insulating layer, and a separate electrolyte reservoir contacting each hole on at least one side of the insulating layer.

23. A device as in claim 22, wherein the array of holes is an n x m array and n and m can be the same or different and each of n and m is an integer of at least 2.

24. A device as in claim 1, further comprising an amplifier to amplify the generated electrical current.

25. A device for generating an oscillating current, comprising an oscillating ion channel, wherein the ion channel is positioned within a membrane spanning a hole having a diameter less than 1 μm.

26. A device as in claim 1, wherein the at least one hole has one common electrolyte reservoir.

27. A method, comprising:

providing at least one membrane positioned between two electrolyte reservoirs, the membrane having at least one oscillating ion channel, and measuring an electrical output from the oscillating ion channel in the membrane.

28. A method as in claim 27, wherein the ion channel oscillates steadily for at least 1 day.

29. A method as in claim 27, wherein the ion channel is selected from the group consisting of a sodium ion channel, a potassium ion channel, a calcium ion channel and combinations thereof.

30. A method as in claim 29, wherein the ion channel is a sodium/calcium ion channel.

31. A method as in claim 30, wherein the sodium/calcium ion channel is formed from a closed ring arrangement of protein subunits.

32. A method as in claim 31, wherein each of the protein subunits is subunit c of ATP synthase.

33. A method as in claim 30, wherein each of the protein subunits is stable for a period of at least one day upon being stored in an organic solvent under an ambient atmosphere.

34. A sensor, comprising:

an insulating layer positioned between two electrolyte reservoirs;

a negative bias electrode and a positive bias electrode, each electrode having one end in electrical communication with respective electrolyte reservoirs, the other ends of the electrodes being connected to a voltage source for applying a voltage and a current detector for measuring current;

at least one hole penetrating the insulating layer; and

an ion channel positioned within the hole.

35. A sensor as in claim 34, further comprising one of the two electrolyte reservoirs being exposed to an atmosphere suspected of containing the analyte.

36. A method for detecting a sample of analyte, comprising:

providing at least one ion channel oscillating at a first frequency;

allowing the sample to bind to the at least one ion channel to cause the ion channel to oscillate at a second frequency; and

measuring the second frequency.

37. A method as in claim 36, wherein the providing step further comprises:

positioning the at least one ion channel into each of the at least one hole penetrating an insulating layer, the insulating layer being positioned between two electrolyte reservoirs; and

immersing one end of each of a negative bias electrode and a positive bias electrode into respective electrolyte reservoirs, the other ends of the electrodes being connected to a voltage source for applying a voltage and a detector for measuring current.

38. A method as in claim 36, wherein a time between the binding and measuring the second frequency is less than about 1 s.

39. A method as in claim 36, wherein a time between the binding and measuring the second frequency is less than about 500 ms.

40. A method as in claim 36, wherein a time between the binding and measuring the second frequency is less than about 100 ms.

41. A method as in claim 36, wherein the amount of analyte in the sample is less than about 1 nM.

42. A method as in claim 36, wherein the amount of analyte in the sample is less than about 500 pM.

43. A method as in claim 36, wherein the amount of analyte in the sample is less than about 100 pM.

44. A method as in claim 36, further comprising derivatizing the ion channel with functional groups to detect a predetermined analyte.

45. A method as in claim 36, wherein the first frequency is at least 0.1 Hz.

46. A device comprising:

an ion channel capable of oscillation; and

an electrical amplifier in electrical communication with the ion channel.

47. A device as in claim 46, further comprising an electrical insulator, wherein the ion channel is located in a hole in the barrier passing from a first side of the insulator to a second side of the insulator, the device further comprising first and second electrolyte reservoirs positioned on respective sides of the barrier and contacting first and seconds ends of the hole, and electrical circuitry constructed and arranged to apply potential across the hole and to measure a change in electrical characteristic resulting in a change in oscillation frequency of the ion channel, amplified by the amplifier.

48. A device comprising:

a barrier having a first side and a second side;

a pore in the barrier, existing in one of an open and a closed state, the closed state preventing ionic communication across the pore and the open state allowing ionic communication across the pore from the first side of the barrier to the second side of the barrier;

a first electrolyte container, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with the a first side of the pore, including container interior walls integral with the barrier; and

a second electrolyte container, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with a second side of the pore, including container interior walls integral with the barrier.

49. A device comprising:

a barrier having a first side and a second side;

a pore in the barrier, existing in one of an open and a closed state, the closed state preventing ionic communication across the pore and the open state allowing ionic communication across the pore from the first side of the barrier to the second side of the barrier;

a first electrolyte container, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with the a first side of the pore; and

a second electrolyte container, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with a second side of the pore, and fastenable to the first electrolyte container.

50. A device comprising:

a barrier having a first side and a second side;

a pore in the barrier, existing in one of an open and a closed state, the closed state preventing ionic communication across the pore and the open state allowing ionic communication across the pore from the first side of the barrier to the second side of the barrier;

a first electrolyte container, fastenable to the barrier, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with a first side of the pore; and

a second electrolyte container, fastenable to the barrier, constructed and arranged to contain an electrolyte and to position the electrolyte in contact with a second side of the pore.

Sub A1

~~51. A device as in any of claims 48-50, wherein the barrier includes an electrical insulator.~~

52. A method for generating at least one oscillating current, comprising providing at least two separate membranes positioned adjacent at least one electrolyte reservoir, each membrane having at least one oscillating ion channel, and simultaneously measuring an electrical output from the at least one oscillating ion channel in each membrane.

53. A device comprising:

a first electrolyte reservoir;

a second electrolyte reservoir;

electrical circuitry connecting the first and second electrolyte reservoirs; and

subunit c of ATP synthase separating first and second electrolyte reservoirs.

Sub A2

54. A device or method as in any preceding claim, including a hole spanned by an insulating membrane containing a pore.

55. A device or method as in any preceding claim, including subunit c of ATP synthase or a derivative.